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Hands-on Simulation versus Traditional Video-learning in Teaching Microsurgery Technique

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Abstract

Bench model hands-on learning may be more effective than traditional didactic practice in some surgical fields. However, this has not been reported for microsurgery. Our study objective was to demonstrate the efficacy of bench model hands-on learning in acquiring microsuturing skills. The secondary objective was to evaluate the aptitude for microsurgery based on personality assessment. Eighty-six medical students comprising 62 men and 24 women were randomly assigned to either 20 min of hands-on learning with a bench model simulator or 20 min of video-learning using an instructional video. They then practiced microsuturing for 40 min. Each student then made three knots, and the time to complete the task was recorded. The final products were scored by two independent graders in a blind fashion. All participants then took a personality test, and their microsuture test scores and the time to complete the task were compared. The time to complete the task was significantly shorter in the simulator group than in the video-learning group. The final product scores tended to be higher with simulator-learning than with video-learning, but the difference was not significant. Students with high "extraversion" scores on the personality inventory took a shorter time to complete the suturing test. Simulator-learning was more effective for microsurgery training than video instruction, especially in understanding the procedure. There was a weak association between personality traits and microsurgery skill.

Key words: microsurgery, training, personality, aptitude

Introduction

Microsurgical skill is essential for neurosurgeons. However, acquiring microsurgical skills is challenging and time consuming. This may keep novices away from microsurgery. Various training methods have been previously reported.[1-3] In Japan, repetitive suturing of gauze fibers with 10-0 nylon using a desk-type microscope is a common microsurgery training method used to learn the precise movements required for microvascular anastomosis.[4] However, holding the 10-0 nylon and needle is too difficult for novices in first practice. An introductory method of microsurgical training for novices is thus required. A previous study reported that the bench model of hands-on learning was more effective than traditional didactic practice at the early stages of surgical training.[5] In that study, Matsumoto et al. found that hands-on learning using a simple bench model simulator of complex skills, such as stone extraction by ureteroscopy, was more effective than didactic instruction.

We hypothesized that the results would be similar during the early stages of microsurgery training. In other words, hands-on learning with simple and large-scale simulators would be a more effective introduction to microsurgery training than traditional video-learning. Our main objective in this study was to compare the acquisition of basic microsurgical skills in medical students who learned using a simple large-scale bench model simulator to that of medical students who learned using an instructional video only.

Acquiring microsurgical skills is difficult, and medical students who are interested in microsurgery

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may wonder whether they have an aptitude for microsurgery. Knowledge regarding the specific skills required to more easily succeed at microsurgery would help these students to choose their subspecialty. The relationships between specific personality traits and surgery have previously been studied.[6-9] Since we assume that microsurgical skill is related to personality, our secondary objective was to determine the relationship between personality and acquisition of microsurgical skills.

Materials and Methods

Participants

Fifth-year medical students at the Nagoya University School of Medicine participated in this study. As we did not want the participants to have any prior microsurgery experience, we recruited students and not residents. Medical students with prior microsurgery training were excluded. The Nagoya University School of Medicine Institutional Review Board approved this study (IRB No. 2015-0084). All of the students provided written informed consent before they participated in this study. The students were divided into two groups by simple randomization.

Materials

Students used Leica S6E desk-type microscopes for practice (Leica Microsystems GmbH, Wetzlar, Germany). The magnification of the microscope was fixed at 12.6x (2.0 × 10 × 0.63) throughout the training. Micro-scissors (PS-1510, Muranaka Med, Japan) and micro-forceps (BONIMED, Muranaka Med, Japan) were used. Commercially available nonsterile 10-0 nylon (Bear Medic, Ibaragi, Japan) was used for microsuturing, and 5-0 nylon (Diadem, Ibaragi, Japan) and surgical forceps (McIndoe Forceps DA111S1, YDM Corporation, Saitama, Japan) were used for suturing on the simulator. The suturing simulator was made at the medical school. Woolen yarn sleds and ethylene vinyl acetate (EVA) sheets were attached to the wooden board (20 × 15 cm) of the simulator (Fig. 1).

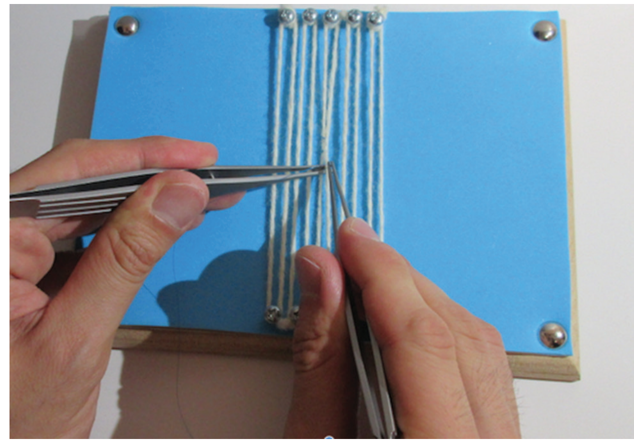

Fig. 1 The suturing simulator and hands-on learning.

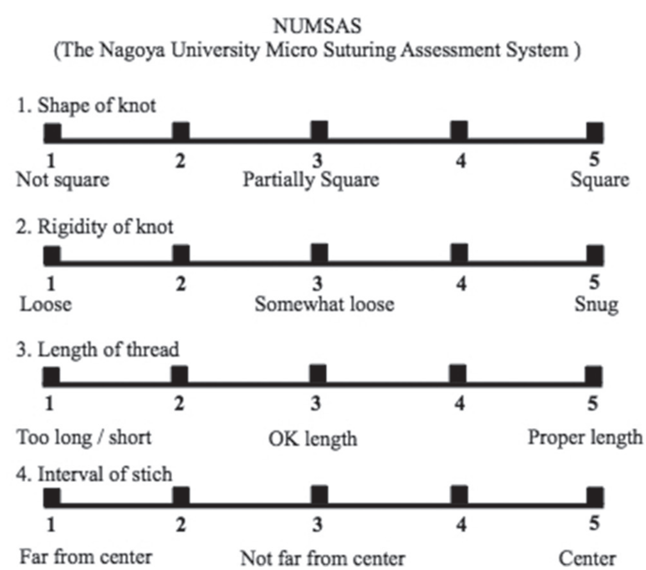

Fig. 2 The Nagoya University Micro Suturing Assessment System (NUMSAS).

We developed a system for grading the microsutures in this study. The Nagoya University Micro Suturing Assessment System (NUMSAS, Fig. 2) includes four components used to assess the quality of knots, i.e., shape of the knot, fixation of the knot, length of thread, and knot interval. These components are scored on a five-point Likert scale. There are many grading systems used to evaluate microsurgical technique.[10-14] The University of Western Ontario Microsurgical Skills Acquisition/Assessment instrument (UWOMSA) includes not only a microvascular anastomosis assessment, but also a microsuturing assessment.[11] We modified the knot-tying assessment of the UWOMSA to develop the NUMSAS.

The NEO-five-factor inventory (FFI) is a widely used personality test used to evaluate five basic personality characteristics. These characteristics are neuroticism (N), extraversion (E), openness (O), agreeableness (A), and conscientiousness (C). This test is based on the five-factor theory.[15] The NEO-FFI has been translated into Japanese and has been validated.[16] The following are simple descriptions for each personality trait.[17]

- The (N) score represents emotional instability.
- The (E) score represents positiveness in social situations.

- The (O) score represents openness to experience.
- The (A) score represents the degree of interaction with society.
- The (C) score represents self-control.

We used the Japanese version of the NEO-FFI designed for University students (Tokyo Shinri, Inc., Tokyo, Japan).[16,17] We scored the test following the NEO-personality inventory revised version (PI-R), which is the NEO-FFI Manual for the Japanese Version, Revised and Enlarged Edition (Tokyo Shinri, Inc., Tokyo, Japan).[16,17]

Study protocol

All participants were provided with a 20-min verbal explanation of the study and then randomized to the simulator-learning and video-learning groups. Students in the video-learning group watched a 10-min instructional video that explained the procedure used to microsuture gauze fiber twice. Subsequently, these students practiced microsuturing with the aid of a microscope for 40 min. They practiced suturing adjacent gauze fibers with 10-0 nylon, tied three knots, and cut the thread using micro-scissors.

The simulator-learning group practiced suturing for 20 min. They sutured adjacent woolen yarn threads on the simulator using two surgical forceps and 5-0 nylon. After completing 20 min of simulator learning, these students practiced microsuturing for 40 min using a microscope similar to that used in the video-learning group. During practice, all students were free to ask questions from the expert instructor.

After 40 min of practice, the students were tested by stitching adjacent gauze fibers and tying three knots. The test was repeated three times and the time required to complete the test was recorded. Students who could not finish the procedure in 60 min were considered to have passed the time limit and were allowed to stop taking the test at any time. Two independent expert neurosurgeons assessed the quality of the knots in a blinded fashion and graded the final products using the NUMSAS. After the knot-tying test, we conducted the NEO-FFI to assess the relationship between surgical skill and personality.

Statistical analysis

The Wilcoxon rank sum test was used to compare the NUMSAS scores of the video and simulator groups. The NUMSAS score considered was the average score from the two independent graders. We used univariate and multivariate linear regression analyses to evaluate the impacts of a learning group, gender, and personality score on the time required to complete the test. The time to complete for students who could not complete the procedure within 60 min or those who gave up on the procedure before completing it was recorded as 3,600 s. Univariate and multivariate linear regression analyses were also used to evaluate the relationship between NEO-FFI and NUMSAS scores. We considered $P < 0.05$ to be statistically significant. The analysis was performed using SAS version 9.4 (SAS Institute, Cary, NC).

Results

The study was conducted from June 2015 to February 2016. Three students who had taken a microsurgery course were excluded. The study thus included 86 fifth-year medical students. The mean age of the participants was 24.19 ± 3.77 years. Sixty-two of the subjects were men and 24 were women (Table 1). Forty-five students were assigned to the video-learning group and 41 students were assigned to the simulator-learning group. Two men assigned to the video-learning group gave up during the final test at the half-way point due to the difficulty of the test. These students' time to finish was recorded as 3,600 s. The other 84 students completed the final test and their times were recorded.

Final product score

When we compared the NUMSAS scores of the simulator-learning and video-learning groups, we found that the median score in the video-learning group was 52.0 points (range = 25–59.5), while it was 54.0 points (range = 22.5–60.0) in the simulator-learning group. The difference between the two groups was not statistically significant ($P = 0.11287$, Table 2). We compared the NUMSAS component scores between the two groups and found that only the length scores were significantly different. The median length score was 13.5 points (range = 7.0–15.0) in the video-learning group and 15.0 points (range = 3.5–15.0) in the simulator-learning group.

Table 1 Study groups and characteristics

	All	Video-learning group	Simulator-learning group
Number of participants	$n = 86$ (Male = 62, Female = 24) (Drop-out = 2)	$n = 45$ (Male = 32, Female = 13) (Drop-out = 2)	$n = 41$ (Male = 30, Female = 11)
Mean Age (years ± SD)	24.19 ± 3.77	24.73 ± 4.82	23.59 ± 1.99

SD: standard deviation.

Table 2 Final product test scores

		Video-learning group All = 43 (Male = 30, Female = 13)	Simulator-learning group All = 41 (Male = 30, Female = 11)	
NUMSAS total score Median (min–max)	All	52.0 (25.0–59.5)	54.0 (22.5–60.0)	0.11287
	Male	51.8 (25.0–58.5)	54.0 (22.5–60.0)	0.15961
	Female	52.5 (43.5–59.5)	53.5 (48.5–59.0)	0.33804
Shape average Median (min–max)	All	11.5 (4.5–15.0)	11.0 (6.0–15.0)	0.73632
	Male	11.0 (4.5–14.0)	10.5 (6.0–15.0)	0.63488
	Female	12.0 (10.0–15.0)	11.5 (8.5–15.0)	0.7706
Knot rigidity average Median (min–max)	All	13.0 (5.5–15.0)	13.0 (7.0–15.0)	0.13391
	Male	12.0 (5.5–15.0)	13.0 (7.0–15.0)	0.1738
	Female	13.0 (10.0–15.0)	14.0 (9.0–15.0)	0.45901
Length average Median (min–max)	All	13.5 (7.0–15.0)	15.0 (3.5–15.0)	0.02673
	Male	13.0 (7.0–15.0)	14.8 (3.5–15.0)	0.05198
	Female	14.5 (11.0–15.0)	15.0 (11.5–15.0)	0.20589
Interval average Median (min–max)	All	15.0 (3.0–15.0)	15.0 (5.0–15.0)	0.4473
	Male	15.0 (3.0–15.0)	15.0 (5.0–15.0)	0.47952
	Female	15.0 (6.0–15.0)	15.0 (13.0–15.0)	0.84139

NUMSAS: the Nagoya University Micro Suturing Assessment System.

The length score was significantly better in the simulator-learning group than in the video-learning group (P = 0.02673, Table 2).

Time to complete

When we compared simulator-learning and video-learning, we found that the mean time to complete the microsurgery test was 1,115.2 ± 695.9 s (mean ± standard deviation [SD]) in the video-learning group (range = 421–3,600 s), and 749.7 ± 425.2 s (mean ± SD) in the simulator-learning group (range = 325–2,090 s). We used univariate and multivariate linear regression analyses to evaluate the impact of learning group and gender on the time to complete (Table 3). The simulator-learning group completed the suturing test in a significantly shorter time than the video-learning group (P = 0.001). We could not find significant differences in time to complete between men and women.

NEO-FFI and time to complete

We also evaluated the relationship between personality inventory scores and time to complete the microsurgery test using univariate and multivariate linear regression analyses (Table 3). Using the T score of the NEO-FFI manual,[16,17] we stratified the students into five groups: very high score (T ≥ 66 points), high score (65 ≥ T ≥ 56), average score (55 ≥ T ≥ 45), low score (44 ≥ T ≥ 35), and very low score (34 ≥ T). The mean score of the N trait was 46.70 ± 11.08 points, while it was 49.03 ± 10.45 for E, 48.36 ± 11.93 for O, 49.73 ± 11.08 for A, and 53.45 ± 11.07 for C. Students with relatively high "E" scores completed the suturing test significantly faster than those with average E scores (estimated regression coefficient = −418.2, P = 0.0118). Students with low A scores completed the suturing test faster than students with average A scores (estimated regression coefficient = −290.9, P = 0.057), although this difference was not significant. We did not find any significant relationships between the N, O, and C trait scores and performance on the suturing test.

NEO-FFI and final product scores

We evaluated the relationship between NEO-FFI and NUMSAS scores using multiple regression analysis (Table 4). The T scores were stratified as described above. We only observed a relationship between NUMSAS scores and agreeableness. Students with relatively high agreeableness scores tended to have lower NUMSAS scores than students with average scores (estimated regression coefficient = −4.1, P = 0.0335). Multiple regression analysis also revealed that women tended to have higher NUMSAS scores than men. However, this difference was not significant (estimated regression coefficient = 2.88, P = 0.0857).

Discussion

Acquiring microsurgical skill is challenging and the existing training methods are too difficult

Table 3 Univariate and multivariate linear regression analyses of personality trait scores and time to complete

Item	Category	n	Univariate			Multivariate		
			Estimate	95% CI	P-value	Estimate	95% CI	P-value
Group	Video	45						
	Simulator	41	−365.5	−609.2 to −121.7	0.0033	−380.1	−606.1 to −154.1	0.001
Gender	Male	62						
	Female	24	−220.6	−501.5 to 60.31	0.1238			
N	Average	30						
	Very low	12	−210.3	0.81 to 3.16	0.175			
	Low	26	69.3	0.55 to 1.6	0.8081			
	High	14	36.46	0.51 to 1.91	0.9586			
	Very high	4	−356.2	0.9 to 7.66	0.078			
E	Average	32						
	Very low	6	111.6	−393.9 to 617.0	0.6653	145.5	−338.1 to 629.1	0.5553
	Low	26	−241.1	−544.1 to 55.89	0.1108	−107.4	−381.3 to 166.5	0.4422
	High	16	−370.2	−718.1 to −22.31	0.037	−418.2	−743.9 to -92.53	0.0118
	Very high	6	113.1	−392.4 to 618.5	0.6611	52.16	−407.3 to 511.7	0.8239
O	Average	29						
	Very low	10	235.0	−188.7 to 658.8	0.277			
	Low	24	78.74	−240.1 to 397.6	0.6284			
	High	15	62.31	−305.2 to 429.8	0.7397			
	Very high	8	−322.4	−783.8 to 139.1	0.1709			
A	Average	35						
	Very low	6	−269.9	−762.5 to 222.7	0.2829	−408.4	−883.7 to 66.89	0.0922
	Low	18	−326.9	−650.3 to −3.57	0.0475	−290.9	−290.1 to −590.5	0.057
	High	19	260.8	−56.88 to 578.5	0.1076	249.9	−48.1 to 547.9	0.1003
	Very high	8	−65.96	−502.9 to 370.9	0.7673	61.03	−365.8 to 487.9	0.7793
C	Average	30						
	Very low	3	37.13	−679.1 to 753.4	0.9191			
	Low	17	−53.65	−412.7 to 305.4	0.7696			
	High	23	−45.88	−373.7 to 281.9	0.7838			
	Very high	13	−79.46	−472.2 to 313.3	0.6917			

A: agreeableness, C: conscientiousness, CI: confidence Interval, E: Extraversion, N: neuroticism, O: openness.

novices. Better methods for introductory microsurgical training are needed. We evaluated the effectiveness of a bench model simulator and compared it to that of traditional video-learning for medical students. A secondary objective was to identify an aptitude for microsurgery using a personality test. The learned skill was completed in a significantly shorter time with simulator-learning than with video-learning. The only difference in NUMSAS scores between the two different training groups was that for suture length, with better scores in the simulator group. Multiple regression analysis revealed that women tended to have higher NUMSAS scores than men. However, this difference was not significant.

When evaluating the relationships between personality traits and time to complete the suturing test, we found that relatively high E scores were associated with significantly faster suturing when compared to average scores.

The simple large-scale bench model makes it easier to grasp the suturing technique using a microscope. Practice with hand motion is likely to be more effective for developing an understanding of the procedure than practice without hand motion. However, the simulator did not seem to affect the

Table 4 Univariate and multivariate analyses of personality trait scores and final product test scores

Item	Category	*n*	Univariate			Multivariate		
			Estimate	95% CI	*P*-value	Estimate	95% CI	*P*-value
Group	Video	43						
	Simulator	41	2	−0.96 to 4.95	0.1855			
Gender	Male	60						
	Female	24	3.3	0.08 to 6.53	0.0448	2.88	−0.4 to 6.15	0.0857
N	Average	30						
	Very low	12	−1.32	−5.98 to 3.34	0.5798			
	Low	25	−0.65	−4.35 to 3.04	0.7289			
	High	13	−0.69	−5.23 to 3.84	0.7637			
	Very high	4	−1.73	−9 to 5.53	0.64			
E	Average	31						
	Very low	5	2.5	−3.96 to 8.96	0.4487			
	Low	26	2.27	−1.29 to 5.83	0.2119			
	High	16	2.72	−1.4 to 6.85	0.196			
	Very high	6	−1.57	−7.55 to 4.41	0.6067			
O	Average	29						
	Very low	9	−0.33	−5.46 to 4.8	0.8999			
	Low	23	0.49	−3.26 to 4.25	0.7975			
	High	15	0.48	−3.8 to 4.76	0.8254			
	Very high	8	4.45	−0.92 to 9.82	0.1046			
A	Average	34						
	Very low	6	−0.25	−6.08 to 5.59	0.9344	−0.05	−5.79 to 5.69	0.987
	Low	18	0.7	−3.14 to 4.54	0.7212	0.26	−3.55 to 4.07	0.8945
	High	18	−4.3	−8.14 to −0.46	0.0282	−4.1	−7.89 to −0.32	0.0335
	Very high	8	0.4	−4.78 to 5.58	0.8794	−0.72	−5.97 to 4.53	0.788
C	Average	30						
	Very low	3	−4.47	−12.65 to 3.72	0.2848			
	Low	16	1.36	−2.83 to 5.54	0.5253			
	High	22	0.93	−2.87 to 4.72	0.6319			
	Very high	13	0.12	−4.37 to 4.61	0.9571			

A: agreeableness, C: conscientiousness, CI: confidence Interval, E: Extraversion, N: neuroticism, O: openness.

quality of the final knots. It may be difficult for novices to produce high-quality knots.[2)]

Our results indicate that hands-on practice with a suturing simulator may be an effective introduction for microsuturing practice under a desk-type microscope.[4)] Novices or young trainees who cannot increase their microsuturing speed should try suturing using simulator learning, as they might then be able to perform microsuturing smoothly. The suturing simulator would also be effective as a component in the microsurgery training course for novices. The efficacy of the microsurgery training course has been reported.[18)] However, time to practice in the training course is usually limited. As far as we know, a microsurgery training course using a simulator has never been reported. We believe that hands-on simulator learning as a part of a microsurgery training course would be a good introduction for novices and would enable them to have a steeper learning curve and more smoothly manage the course.

We found that women tended to have higher final products test scores, although this difference was not statistically significant. Our results differ from those of previous reports, as some studies have reported higher dexterity in men.[19-21] However, most previous articles have focused on laparoscopic surgery, where visual-spatial perception, perceptual ability, and psychomotor skills have significant influence on performance.[22-24] Microsurgery requires different abilities than laparoscopic surgery. For example, precise movements without tremor are required. It has been reported that women have better hand stability and less tremor than men.[25,26] In contrast to results from studies of laparoscopy, women participating in this study seemed to be better than men in learning microsurgery skills.

Analysis of the relationship between personality traits and surgical skill revealed that high extraversion was associated with shorter than average suture completion times. Previous studies have reported that surgeons have higher extraversion, openness, and conscientiousness scores than the general population, although they have lower agreeableness scores.[27] Others have also reported significantly higher extraversion and conscientiousness scores and lower neuroticism and agreeableness scores.[6] Unlike previous studies, we did not find a correlation between personality traits scores and time to complete the learning test, except for a correlation with extraversion. These differences in results may be explained by the fact that the previous studies had recruited surgeons and not medical students. A previous study also suggests that the surgeons have higher extraversion, openness, and conscientiousness scores, and lower agreeableness during their surgical residency.[7] This is in line with other reports of personality change throughout the life span of surgeons.[28] Our results indicate that students with higher extraversion scores already have the "quick hands" needed for microsurgery. We assume that surgeons acquire higher emotional stability, openness, conscientiousness, and lower agreeableness through their surgical residency and that higher extraversion is endowed by nature.

Limitations

We did not detect any significant differences between NUMSAS scores, except for length. We thus presume that our grading system might not be objective. In fact, both graders complained that it was difficult to objectively assess the shapes of the knots. In addition, the magnifications of the microscopes used might not have been sufficient to determine whether the knot was square. To objectively assess the quality of the procedure, a motion-tracking system would be helpful, although it is very expensive.[13,29-32] The existing grading system[12,30] was not expensive, but it was somewhat subjective.[14,31,32] The grading system was time consuming.[32] Therefore, a more efficient and precise grading system is needed.

Conclusion

Simulator-learning was more effective in introducing microsurgical training than traditional video instruction. Thus, this type of learning would increase the effectiveness of the training curriculum for microsurgery novices. Women tended to have final products with higher quality than those produced by men, although this difference was not significant. We found some relationships between personality traits and microsurgery skill. However, the results are not yet sufficiently clear to guide medical students in the choice of their subspecialty. Further research is required to clarify the aptitude for microsurgery and help medical students who are interested in its practice.

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Conflicts of Interest Disclosure

There is no conflict of interest concerning this study. The authors (YS, SO, KS, YA, and TW) have registered online self-reported COI Disclosure Statement Forms through the website for the Japan Neurosurgical Society members.

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